PROBLEMS

Gas Phase Equilibria

1. What are the equilibrium constant expressions K_c and K_p for each of the following reactions?

(a) $2N_2O_5(g) \rightleftharpoons 4NO_2(g) + O_2(g)$

(b) $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$

(c) $SO_2(g) + \frac{1}{2}O_2(g) \rightleftharpoons SO_3(g)$

(d) $P_4(g) + 5O_2(g) \rightleftharpoons P_4O_{10}(g)$

2. The reaction of nitrogen with oxygen to give nitrogen monoxide,

$$N_2 + O_2 \rightleftharpoons 2NO$$

has an equilibrium constant of 2.5×10^{-3} at 2100°C.

(a) What is the expression for the equilibrium constant?

(b) What are the units of the equilibrium constant?

3. The equilibrium constant for the equilibrium

$$N_2O_4(g) \rightleftharpoons 2NO_2(g)$$

at 100°C is 0.212 mol L^{-1}. What is the value of the equilibrium constant for the same reaction written as follows?

(a) $2NO_2(g) \rightleftharpoons N_2O_4(g)$

(b) $NO_2(g) \rightleftharpoons \frac{1}{2}N_2O_4(g)$

4. At 425°C, $K_c = 300$ mol^{-2} L^2 for the reaction in which methanol, CH_3OH, is synthesized from hydrogen and carbon monoxide:

$$2H_2(g) + CO(g) \rightleftharpoons CH_3OH(g)$$

If the initial concentrations of H_2, CO, and CH_3OH are 0.10 mol L^{-1}, is the system at equilibrium?

5. When the reaction

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

had reached equilibrium, the concentrations of the reactants and the products were found to be $[SO_2] = 0.010M$, $[SO_3] = 0.100M$, and $[O_2] = 0.20M$. What is the value of K_c?

6. Dinitrogen tetraoxide dissociates to nitrogen dioxide according to the equation

$$N_2O_4(g) \rightleftharpoons 2NO_2(g)$$

In a mixture of the two gases at 100°C the concentrations were found to be $[N_2O_4] = 0.10M$ and $[NO_2] = 0.12M$.

(a) What is the value for the reaction quotient of the mixture?

(b) Given that $K_c = 0.212$ mol L^{-1} at 100°C, is the system at equilibrium?

(c) If not, will $[NO_2]$ increase or decrease as equilibrium is achieved?

(d) What are the final equilibrium concentrations of NO_2 and N_2O_4? What is the value of K_p at 100°C for this reaction?

7. What are the equilibrium expressions, K_c and K_p, for each of the following heterogeneous reactions?

(a) $C(s) + O_2(g) \rightleftharpoons CO_2(g)$

(b) $MgCO_3(s) \rightleftharpoons MgO(s) + CO_2(g)$

(c) $2NaHCO_3(s) \rightleftharpoons Na_2CO_3(s) + CO_2(g) + H_2O(g)$

(d) $ZnO(s) + CO(g) \rightleftharpoons Zn(s) + CO_2(g)$

(e) $3Fe(s) + 4H_2O(g) \rightleftharpoons Fe_3O_4(s) + 4H_2(g)$